PILOT STUDY OF STAND-BIASED DESKS TO REDUCE SEDENTARY TIME IN HIGH SCHOOL STUDENTS

A Thesis

by

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ABSTRACT

Purpose: The purpose of this pilot study was to identify any difference between sitting and standing time in high school students' pre and post stand-biased desk intervention.

Methods: ActivPal3™ activity monitors were affixed to 25 Bryan Collegiate High School students' pre and post stand biased-desk intervention. After attrition, 18 of the original 25 students were included in the final analysis. The standing and sitting time data provided by the monitors was compared pre and post stand-biased desk intervention.

Results: Descriptive statistics and a two-sided t-test were analyzed to determine any difference between pre and post intervention sitting and standing times. The data analysis indicated a significant reduction of sitting time post stand-biased desk intervention ($p<0.0001$) and a significant increase in standing time, post stand-biased desk intervention ($p<0.0001$).

Conclusions: Standing desks have the potential to reduce sedentary behavior and increase active behavior for high school students during the school day.

DEDICATION

This thesis is dedicated to my wife Sarah Morar Schneider, without whom, I would be lost, and my daughter Lillian Irene Schneider, without whom, I would be significantly more rested but significantly less joyful. I would like to recognize my parents, Nancy and Tony Schneider, for supporting me over the last 33 years, now that Lillian Irene is here, I can truly appreciate their sacrifice. I would also like to thank my Grandmother Norma Irene Vaughn for be my biggest fan and supporter. Finally I would like to thank everyone at the School of Public Health, and Mark Benden in particular, for giving a non-traditional student (in numerous ways) a chance.

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INTRODUCTION

Obesity

The United States is currently grappling with obesity and the detrimental effects it has on society. The prevalence of obesity in the U.S. population has steadily increased over the last several decades, and while obesity rates have leveled off, the prevalence of obesity in the United States remains unsustainably high. The latest data shows a 34.9 percent obesity rate among American adults. This astronomically high rate has far reaching health and economic repercussions, both for obese individuals and for the American society as a whole [1,2].

Obesity can lead to numerous acute and chronic ailments. Health ailments including, but not limited to, type 2 diabetes, heart disease, and hypertension are paired with musculoskeletal maladies to reduce the quality of life, and produce a higher overall mortality rate for obese individuals [3]. A recent meta-analysis of all-cause mortality rate in obese and overweight individuals, using 97 studies, found that obese individuals (defined as a BMI of 30 or over) had significantly higher all-cause mortality than their normal weight (defined as a BMI of 18.5-24.9) counterparts [4].

The economic impact of obesity can be quantified in increased health care and insurance cost. The rise in healthcare and insurance cost is tied to the increase of chronic disease in obese individuals. These chronic diseases require costly treatments, often for the duration of the obese individual's life. A study looking at the economic impact of obesity placed the price tag of obesity in the United States at 75 million dollars per year and rising [5]. Another systematic review of the cost of obesity found that obese individuals spend approximately 30 percent more in health care over their lifetimes than their normal weight counterparts [6]. Finally, another study found that obesity accounted for 209.7 billion dollars in health care costs (in 2008 dollars) and that 20.6% of U.S. dollars spent on healthcare go to obesity related diseases [7]. The obese individual alone does not suffer this increase in health care costs. Instead, through insurance-pooled risk, everyone with health insurance pays higher premiums to counteract the increased funds dedicated to obese individuals.

Furthermore, obesity negatively affects the economy through lost work time. As noted above, obese individuals suffer from higher rates of chronic disease, and subsequently miss more workdays than normal weight individuals. In addition to absenteeism, presenteeism, which is considered decreased or impaired work ability, is found at a much higher rate in obese workers. One study found that obese workers were significant more likely report lost productive time (from absenteeism or presenteeism) in the previous two weeks than their overweight and normal weight peers [8]. Another study placed the aggregate cost attributable to obese full-time employees at 73.1 billion dollars. It also found that workers with a body mass index >35 accounted for 37% of the obese population but were responsible for 61% of excess costs [9]. Obesity is not a condition whose impact is only felt by the afflicted individual, but instead, can be felt in real terms by everyone in society.

Childhood and Adolescent Obesity

Childhood and adolescent obesity, much like adult obesity, takes a terrible toll on both the obese child or adolescent and society as a whole. This issue is currently being diligently researched, and numerous interventions have been, and are being, implemented in an attempt to reverse the childhood and adolescent obesity trend. Recently, there has been good news on the childhood and adolescent obesity front. Data indicates that the rate of childhood and adolescent obesity, which has been increasing steadily over the previous decades, has begun to level off. Across most age and ethnic groups, obesity rates have stagnated or decreased between 2003 and 2012 [1,10-12]. Unfortunately, even with this progress, current childhood and adolescent obesity rates are still unsustainably high. Childhood and adolescent obesity causes physical, mental, and emotional issues in many obese children and adolescents.

Obesity has deleterious effects on the obese child or adolescent. In particular, childhood type 2 diabetes, almost unheard of in previous decades, is currently establishing a foothold in the child and adolescent demographic [13,14]. Type 2 diabetes in children is especially troubling, because diabetes slowly degrades numerous organ systems. The longer an individual has diabetes, the more time the disease has to destroy the body. Furthermore, doctors struggle to properly diagnose type 2 diabetes in children, and children struggle to self-regulate type 2 diabetes, which can lead to under diagnosis and poor regulation in children and adolescents [15,16]. In addition to suffering from early onset chronic diseases like type 2 diabetes, obese children and adolescents suffer from lower health related quality of life compared to their normal weight peers. This results in more school absences and doctors' visits for obese children and adolescents, putting a financial strain on parents and an academic strain on the obese child [17]. Finally, obese children and adolescents are more likely to transition to obese adults than their healthy weight peers, and subsequently, experience the health and economic impacts associated with adult obesity [18-20].

Mental and emotional issues are often associated with childhood and adolescent obesity. Obese teens report feeling intense social stigma and social rejection [21]. Obese teens report feeling ostracized from their peer group, and report higher rates of depression than their normal weight peers. They are also more likely to report being bullied in school. Obese teens exhibit lower self-esteem and self-efficacy in comparison to teens that fall into the normal weight category [21,22]. Grade school children, both male and female, report more teasing behavior from their peers as their body mass index (BMI) increases. Female students report more teasing as their BMI increases and male students report that teasing behavior bothers them more as their BMI increases [23]. Childhood and adolescent obesity has a negative effect on the health and mental well-being of the affected child or adolescent. Therefore, measures should be taken to understand the causes of childhood and adolescent obesity, and interventions should be developed to reduce the rate of childhood and adolescent obesity in the population.

Sedentary Behavior

Sedentary behavior has been linked to increased rates of obesity in adults, adolescents and children. Sedentary behavior is any behavior that does not increase energy expenditure above resting levels. These behaviors include sitting, sleeping, and lying down, and are often associated with screen-based entertainment. The more sedentary behavior a person engages in, the harder it is to balance the calorie/energy expenditure equation. When a person consumes more calories than they expend, weight gain is the inevitable consequence [24-28]. Children and adolescents tend to struggle with calorie intake regulation because they have less control over their diet than adults. In fact, it has been found that as sedentary behavior in children increase, the amount of calories consumed increases [29].

In addition to sedentary behavior at home, children and adolescents face at least eight hours scheduled sedentary behavior at school five days a week. This eight hour time period can easily turn into nine or ten hours if an extended bus ride to and from school is included. Physical education classes and recess were used reduce sedentary behavior at school in the past, but as school budgets are cut and more emphasis is put on standardized test scores, physical education and recess are often the first programs cut, further increasing sedentary school time [22,26]. Sedentary behavior has been closely linked to increased mortality. Men spending more than 10 hours a week driving (sedentary behavior) had an 82% greater risk of dying from cardiovascular disease. Men who reported spending over 23 hours a week driving and television time (sedentary behavior) had a 64% greater risk of dying from cardiovascular disease [30].

This makes poor diet and physical inactivity the second highest cause of preventable mortality in the United States, only behind tobacco use [30]. With the negative effects of sedentary behavior clearly defined, school interventions have been implemented to reduce sedentary behavior in school-aged children.

Physical Education Interventions

The majority of school interventions implemented to reduce student weight gain have focused on increasing activity through physical education classes. The results from these studies found only modest results [31-33]. A meta-analysis of 64 weight gain prevention studies found that only 21 percent of the interventions implemented produced statistically significant weight gain prevention. The interventions that tended to be most successful required at least 40 hours of total intervention time [31].

Unfortunately, interventions that require extended hours and long durations are difficult to implement. These interventions find themselves in direct competition with classroom time, and require a significant investment by the school in time and resources. Intensive interventions, at minimum, require additional training, and sometimes require additional personnel. The funding for these programs often comes directly from the school's budget. As school budgets expand and contract, funding for these programs is sporadic, reducing the effectiveness of the intervention [31].

Furthermore, according to a report from the Institute of Medicine, forty-four percent of the nation's school administrators have cut time from physical education, the arts, and recess and reallocated the time to math and science in order to meet increasing standardized test score demands [34]. Regardless of whether physical education programs are being cut because of budgetary or time restraints, changes to the actual school environment may provide more significant and consistent results than physical education interventions.

School Environment Interventions

Unlike physical education interventions, environmental interventions to reduce sedentary behavior require a one-time expenditure by the school district, and this money generally comes from capital improvement funds instead of from the individual school budget. Additionally, school environment interventions require no additional training or school personnel. Changing the school environment is as simple as changing classroom furniture.

This type of environmental change has been attempted in elementary schools, but has never been undertaken in a high school. In elementary schools, the change from traditional seated desks to stand-biased desks yielded tangible results [35-37]. One study found that Elementary students using stand-biased desks showed an increase in both physical activity and energy expenditure during the school day. An increase in physical activity and energy expenditure is linked to a reduction in sedentary time [35]. While the elementary school environment is different from the high school environment, both require extended time at a desk. Changing furniture to reduce sedentary behavior has also been implemented in industry.

In industry, numerous studies have found that removing traditional seated desks and replacing them with standing or stand-biased desks significantly reduces sedentary time in office workers [38-40]. A study found that the introduction of stand-biased desks into the workplace reduced worker sedentary time by 21 percent over a 40-hour workweek [38]. School environments, and in particular, high school environments, closely mirror office environments where long periods of sitting are required. Therefore, the effects of incorporating stand-biased desks into a high school environment may mirror the effects found in industry.

METHODS

Study Design

This project utilizes a pre/post intervention, within subjects, study design. The pre/post intervention study design has been utilized in other school based sedentary lifestyle intervention studies [35]. This study design assists in isolating the stand-biased desk's effect on sedentary behavior. A within subjects comparison to evaluate the pre/post data was utilized. All data collection procedure were approved by Texas A&M IRB (TAMU-IRB) and Bryan Independent School District.

Data Collection: Pre-Intervention

This study is an offshoot of a larger project. The larger project entails the recruitment of 100 students from Bryan Collegiate High School. These students were recruited using informative handouts, explicitly detailing all requirements of participating in the study, distributed by Bryan Collegiate teachers. To participate in the study, students were required to have a signed parent permission form. This parental permission form was incorporated in the recruiting handout. These handouts were distributed on a Monday and collected on the subsequent Friday. Out of the 100 recruited students, 25 were randomly selected from the pool of 100 collected permission forms to participate in the ActivPal3™ portion of the study. The remaining 75 students participated in a separate portion of the study utilizing armband activity monitors. All participating students were asked to give their individual verbal consent to participate in the study. All participants in the pre-intervention portion of the study used seated tables (Figure 1) when in a Bryan Collegiate High School classroom.

Photo Courtesy of thecornerstoneforteachers.com"

Figure 1 – Classroom with Tables

Once the students turned in their parental permission form and gave their verbal consent for the ActivPal™ portion of the study, their height and weight was collected using a stadiometer (Charder, HM-200Portstad, Taichung City, Taiwan) (Figure 2) to measure height and an electronic weight scale (A&D Medical, UC-321 ProFIT Precision Personal Health Scale, San Jose, California) (Figure 3) to measure weight. Height was recorded in centimeters and weight was recorded in kilograms. Student height and weight was used to establish individual student body mass indices (BMI). Race, gender, and age were recorded using student self-reporting during the assent process.

"Photo Courtesy of Charder™ "

Figure 2 – Stadiometer

"Photo Courtesy of A&D Medical™"

Figure 3 – Weight Scale

The wearable monitor utilized in this study was the ActivPal3™ posture monitor (PAL Technologies, ActivPal3™, Glasgow, UK) (Figure 4). The ActivePal3™ monitor is a fifteen-gram, 53x35x7 millimeter activity monitor that is affixed to the front mid-point of the participant’s thigh. The ActivPal3™ monitor uses a 3-axis accelerometer to monitor and record subject movement throughout an assigned period of time. The monitor also contains an inclinometer to determine leg orientation, which translates to posture. The monitor provides several measurements, including time spent sedentary, time spent standing, time spent stepping, a step count, stepping cadence, and activity score estimated in metabolic equivalents (METS). For this study, only sitting time and standing time was assessed. The ActivPal3™ (Figure 4) has been validated as an objective and accurate measurement tool in numerous studies (41,42,43,44)[41-44].

““Photo courtesy of Paltechnologies Limited ™”

Figure 4 – ActivPal3™

The ActivPal3™ must be programmed before it can be affixed to a participant. In order to accomplish this, the AcitvPal3™ software was downloaded from the ActivPal3™ website. Once the program was downloaded the ActivPal3™ was connected to a Windows based computer using the ActivPal3™ data port and device charger. Once the data port and device charger was connected, a programming menu opened. The ActivPal3™ requires a set time for data collection to begin and end. All data collection began at 11 am on the day the ActivPal3™ was applied and ended three days later at 11 am.

To affix the ActivPal3™, it must first be waterproofed. This was accomplished by inserting the ActivPal3™ in a finger cot (Figure 5) and then sealing the ActivePal3™in Tegaderm film ™ (3M Company, Tegaderm Film, Maplewood, Minnesota) (Figure 6). After waterproofing the ActivPal3™, it was affixed to the participant’s leg using a dual layered hydrogel pad (Figure 7) and a Tegaderm™ film to further secure and seal the device to the participant's thigh (Figure 8).

“Photo Courtesy of Fingercots.net”

Figure 5 – Finger Cot

"Photo Courtesy of Tegaderm™"

Figure 6 – Tegaderm Film ™

"Photo Courtesy of 3M™"

Figure 7 –Dual Sided Hydrogel Pad

"Photo courtesy of Paltechnologies Limited ™"

Figure 8 - ActivPal3™ Placement

The ActivPal3™ was applied during the participants' lunch period in order to eliminate any classroom disruption. Lunch was the preferred application time for Bryan Collegiate High School administrators. The application of the ActivPal3™ occurred in the Bryan Collegiate High School teachers' lounge to ensure participant privacy. The participant was individually called from their lunch period and escorted by a researcher to the teacher's lounge. The student was issued drawstring athletic shorts, and asked to change in the teacher's lounge bathroom. If the student was already wearing shorts, this step was omitted. Once the student was wearing shorts, the student affixed and sealed the ActivPal3™ to their leg with gender appropriate supervision. The ActivPal3™ must be correctly oriented on the mid-thigh, with the curved portion of the monitor pointing up (a drawing used to orient the ActivPal3™ is located on the monitor). Once verified that the ActivPal3™ had been properly affixed, the student returned to the bathroom, changed out of the athletic shorts, and returned to lunch.

The ActivPal3™ was worn for seventy-two consecutive hours, providing three days of uninterrupted data collection. The seventy-two hour time period was set by previous research on stand-biased desks. Results from this previous work indicated seventy-two hour activity average of a student was the same as their one hundred and twenty hour activity average [35-37]. The participant can go about their regular activities without any interference from the ActivPal3™, with the only exception being that the ActivPal3™ not be completely submerged in water. The participants were instructed to take showers instead of baths while they wore the ActivPal3™. The participants were provided extra gel pads and Tegaderm™ in case the ActivPal3™ became dislodged. If the ActivPal3™ became dislodged, the participant was instructed to apply the device as soon as possible and to inform a participating teacher or administrator to ensure the accuracy of the data.

At the conclusion of data collection, a researcher returned to the school during the student's lunch period. The student was again escorted from the lunchroom to the teachers' lounge. They were issued a plastic bag with their participant number and were instructed to remove the ActivPal3™ in the bathroom, remove the waterproofing, place the ActivPal3™ into the issued plastic bag, and return the bag to the researcher. Each participant received twenty-five dollars for their participation in the pre-intervention portion of the study.

Data Collection: Post-Intervention

During Bryan Collegiate High School's winter break, 300 stand-biased desks were installed in participating teachers' classrooms, and their traditional seated desks, in this case, tables and chairs, were removed. The stand-biased desks were adjusted to varied heights in order to accommodate the different student heights found in the 450 students attending the school. Roughly 75% of the classrooms at Bryan Collegiate High School were equipped with stand-biased desks (Figure 9). The number of desks was limited by the funds provided in the CDC grant and the need for other desk designs in some classrooms such as science or music.

"Photo courtesy of Stand2Learn™"

Figure 9 – Stand-Biased Desk

After a three-month acclimation period, a researcher returned to the school in March and followed the same protocol instituted during the pre-intervention data collection for the post intervention data collection. The same students again had their heights and weights recorded (using the same instruments as in the pre-intervention data collection) and had an ActivPal3™ affixed to their thigh. Three consecutive days of twenty-four hour data was again collected. The students received another twenty-five dollars once they completed the post-intervention portion of the study.

Data Analysis

Data Analysis compared pre and post intervention data within individual subjects. First the pre-intervention data was entered into a spreadsheet for each student. This required the three eight-hour school days (defined as all time between 8 am and 4 pm) to be separated from the twenty-four hour data. In total, twenty-two hours of school time data was used in this analysis. The ActivPal3™ software provides an hourly breakdown of the data. This was used to enter the relevant data into the spreadsheet. The data categories for this pilot study are as follows:

- **Time Sitting**
- **Time Standing**

These twenty-two data points were summed to provide a composite sitting and standing time for the pre and post intervention. A delta column was added to the spreadsheet for each category in order to show any change in terms of minutes standing and sitting between the pre and post portions of the study.

A paired student T-Test was used to identify any statistically significant changes in time sitting and time standing for each student from the pre and post intervention time periods.

Time Sitting Hypothesis

$\mathbf{H_o}$: Time Sitting:

Mean sitting time for the pre and post intervention time periods are equal.

$\mathbf{H_a}$: Time Sitting:

There is a change in time sitting between pre and post intervention.

Time Standing Hypothesis

$\mathbf{H_o}$: Time Standing:

Mean standing time for the pre and post intervention time periods are equal.

$\mathbf{H_a}$: Time Standing:

There is a change in time standing from pre intervention to post intervention.

STATISICAL ANALYSIS / RESULTS

Data Processing

Data were uploaded from the ActivPal3™ using the manufacturer's software. The ActivPal3™ provides raw data in an Excel™ sheet and produces a summary data sheet; both the raw data and the summary data sheet were used in data analysis. Participant identity was protected by the issuance of participant numbers. This unique participant number was used throughout the study. Data processing was performed by the primary researcher and then spot-checked for accuracy by another researcher.

Data Analysis

Participant data were analyzed using the statistical software SASS™ and basic analysis was preformed using Excel™. The dependent variables in this study were time sitting during school hours (defined as 8 A.M. to 4 P.M.) and time standing during school hours. The independent variable for this study was desk type (seated and stand-biased). The study design used for this research was pre intervention and post intervention within subjects design. A paired t-test was used to analyze each participant's pre intervention and post intervention data. Excel™ was used to calculate the hourly averages of pre and post intervention sitting and standing times.

Data Cleaning and Data Exclusion

There were no outliers found after reviewing the distribution of the data. However, seven participants had to be excluded from the original twenty-five participants. Two participants left the school, preventing post intervention data from being collected. One participant was excluded because of an ActivPal3™ malfunction during pre-intervention data collection. Two participants were excluded because of non-compliance (defined as three or more consecutive school hours with no data recorded, indicating the removal of the ActivPal3™) during the pre-intervention portion of data collection. Two participants were excluded because of non-compliance during the post-intervention portion of data collection. In total, data from 18 subjects were used for analysis.

Participant Demographics

Figures 10 through 14 show the age, grade level, gender and race of the final 18 participants included in this study.

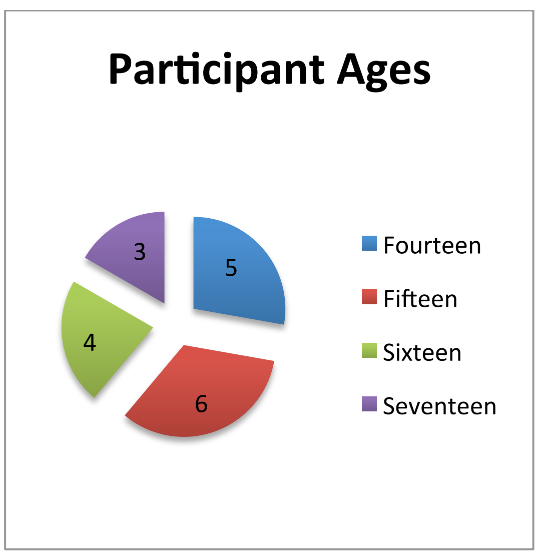

Figure 10 – Participant ages.

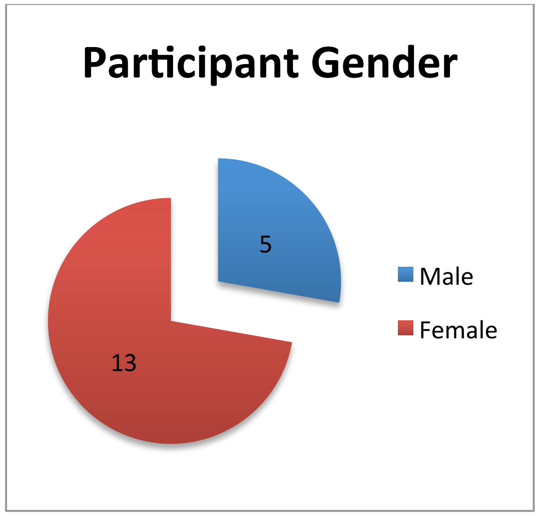

Figure 11 – Participant gender.

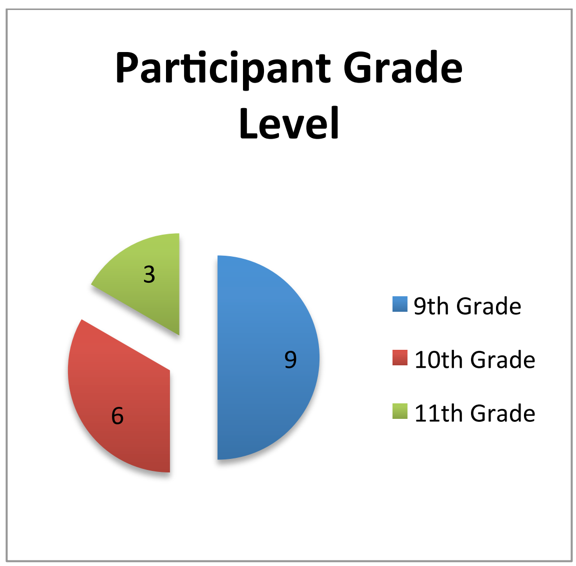

Figure 12 – Participant grade level.

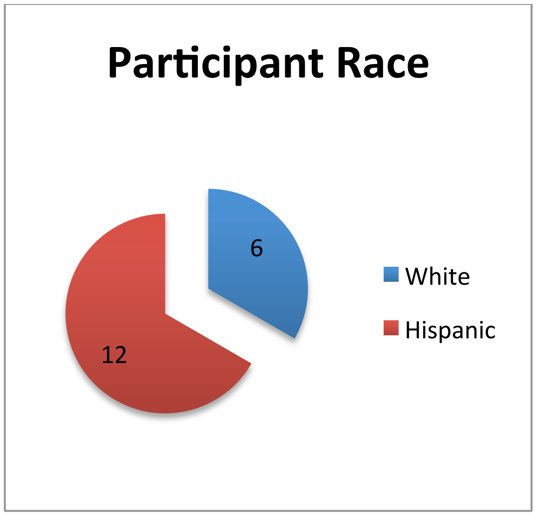

Figure 13 – Participant race.

Results

Pre and Post Intervention Sitting Times

The Quantile-Quantile plot shown in Figure 14 shows the pre and post intervention sitting time differences are close to normally distributed.

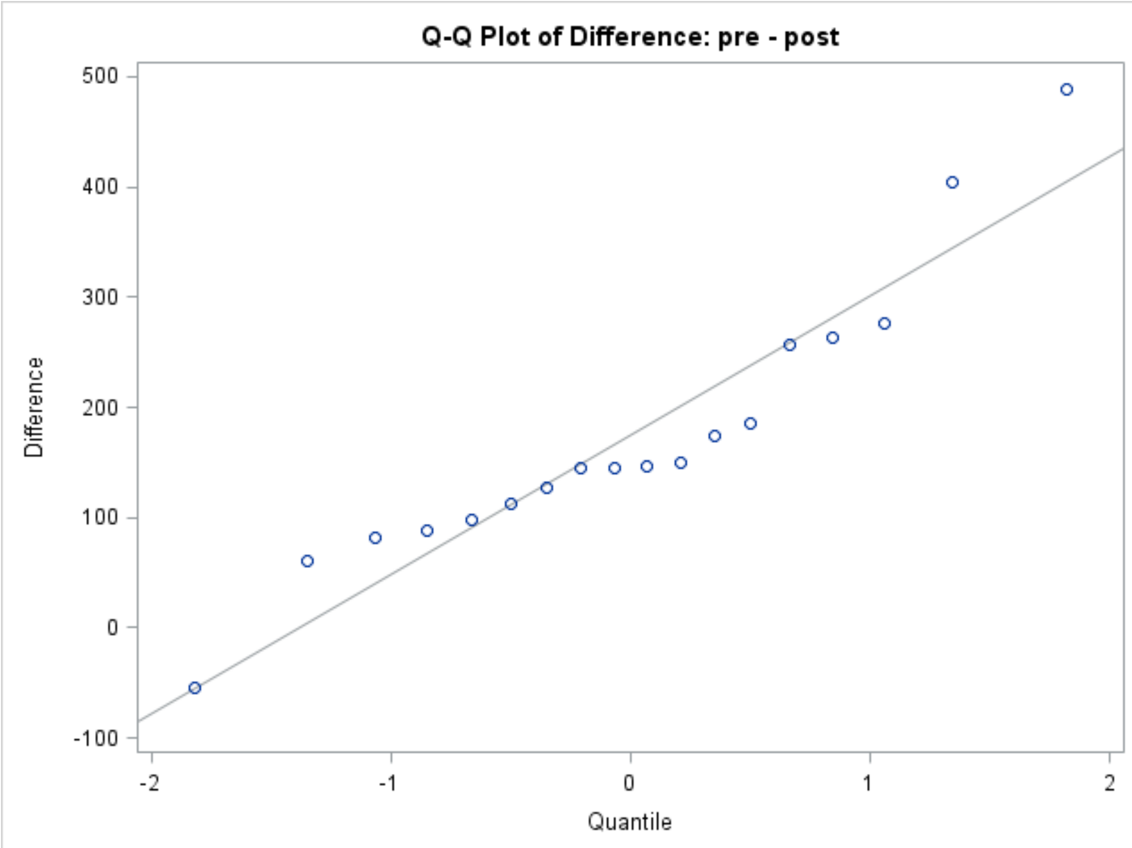

Figure 14 - Sitting Time Difference Q-Q Plot

Figure 15 illustrates the differences between pre and post intervention sitting times for each subject. Seventeen out of eighteen participants reduced their overall sitting time post stand-biased desk intervention.

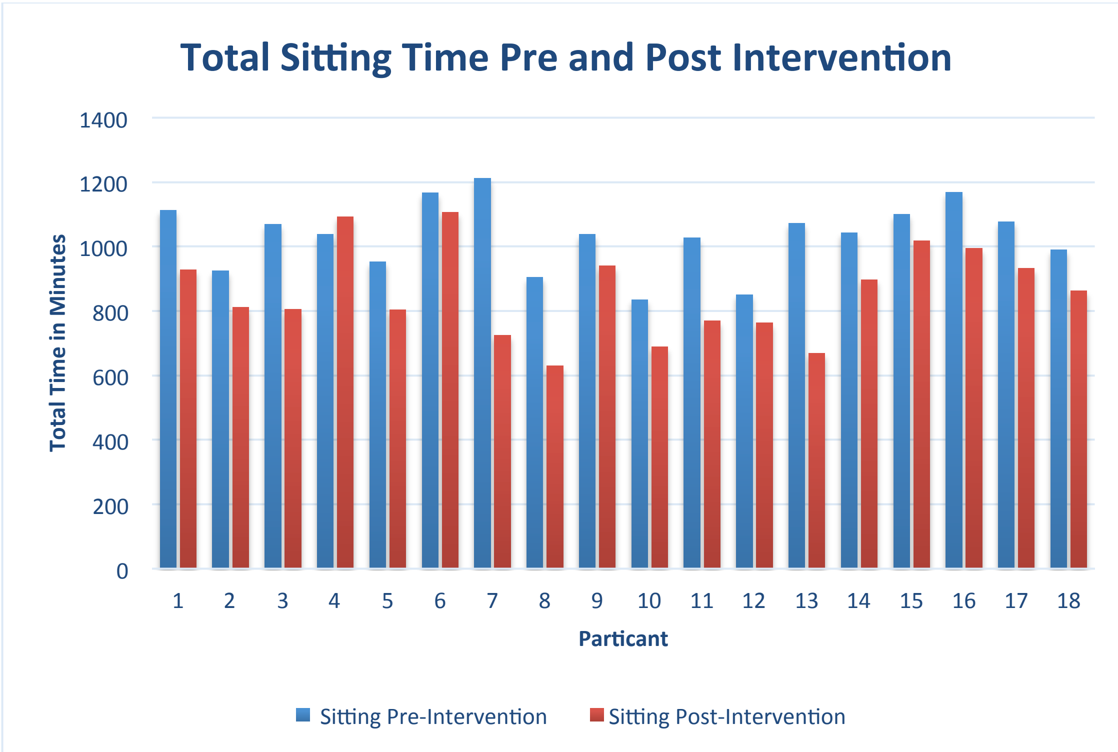

Figure 15 – Total Sitting Time Pre and Post Intervention

Figure 16 shows the hour-by-hour averages for the eighteen participants in the study. For every hour, except the 11 a.m. hour, students on average sat less after stand-biased desks were installed in their school. The 11 a.m. hour is unique because it is the lunch hour at Bryan Collegiate High School. The times converge because all students are in the cafeteria during lunch and must stand in line for their food, causing their sitting times to decrease during their lunch period.

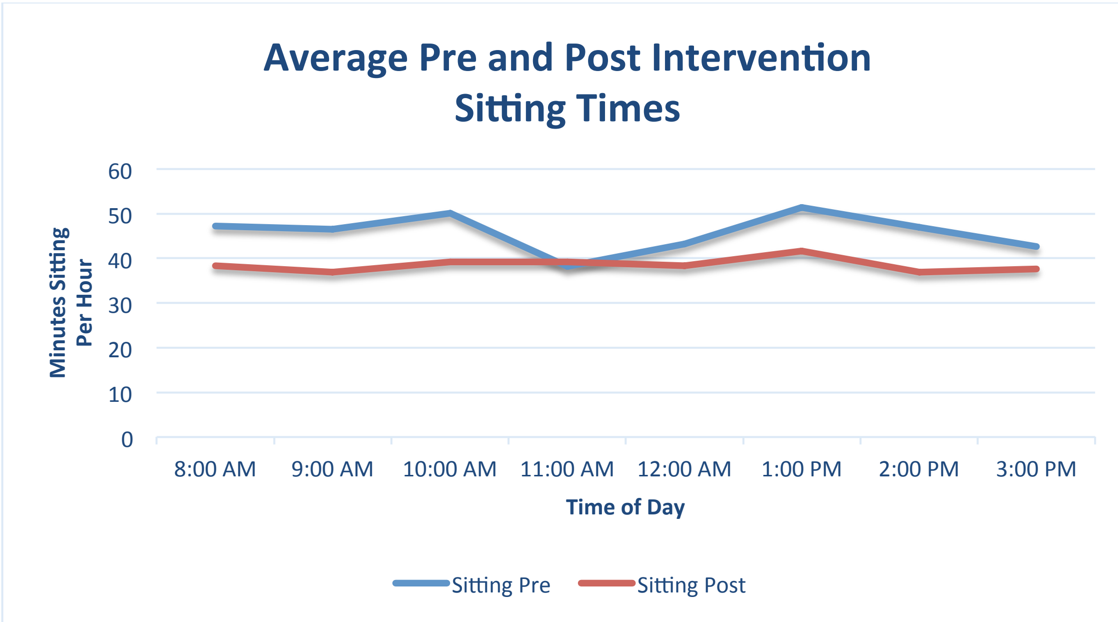

Figure 16 – Average Pre and Post Intervention Sitting Times

Table 1: Sitting Pre and Post Paired T-Test Results

N	Mean Difference (in minutes)	Standard Deviation	t-Value	Pr > t
18	174.8	126.6	5.86	<0.0001

Table 1 shows the results of the Paired Student T-Test on the Pre and Post intervention data. The mean difference in sitting minutes between pre and post intervention is 174.8 minutes (also seen in Table 2). The standard deviation between pre and post intervention times was 126.6 minutes. All data points for this study fall within 1 standard deviation. The T-Value of 5.86 supports statistically significant findings. This is supported by P<0.0001.

Table 2: Sitting Summary Descriptive Statistics

N=18	Pre-Intervention	Post-Intervention	Delta
Mean Time Sitting (in minutes)	1032.4	857.6	174.8

Table 2 shows that over the 22-hour period (approximately 3 school days) of pre and post intervention testing, students, on average sat three fewer hours after the stand-biased desk intervention. This is on average approximately 1 hour less of sitting per school day

Pre and Post Intervention Standing Times

The Quantile-Quantile plot shown in Figure 17 shows the pre and post intervention standing time difference are close to normally distributed.

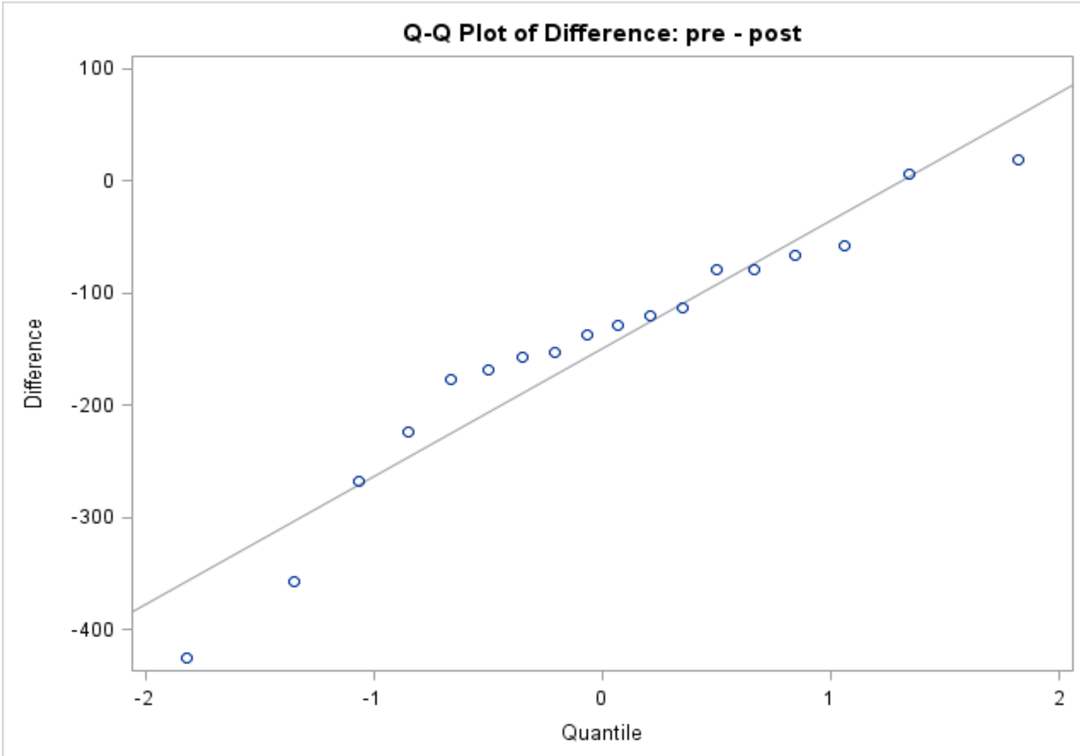

Figure 17 – Standing Time Difference Q – Q Plot

Figure 18 illustrates the differences between pre and post intervention standing times for each subject. Sixteen out of eighteen participants increased their overall standing time post stand-biased desk intervention.

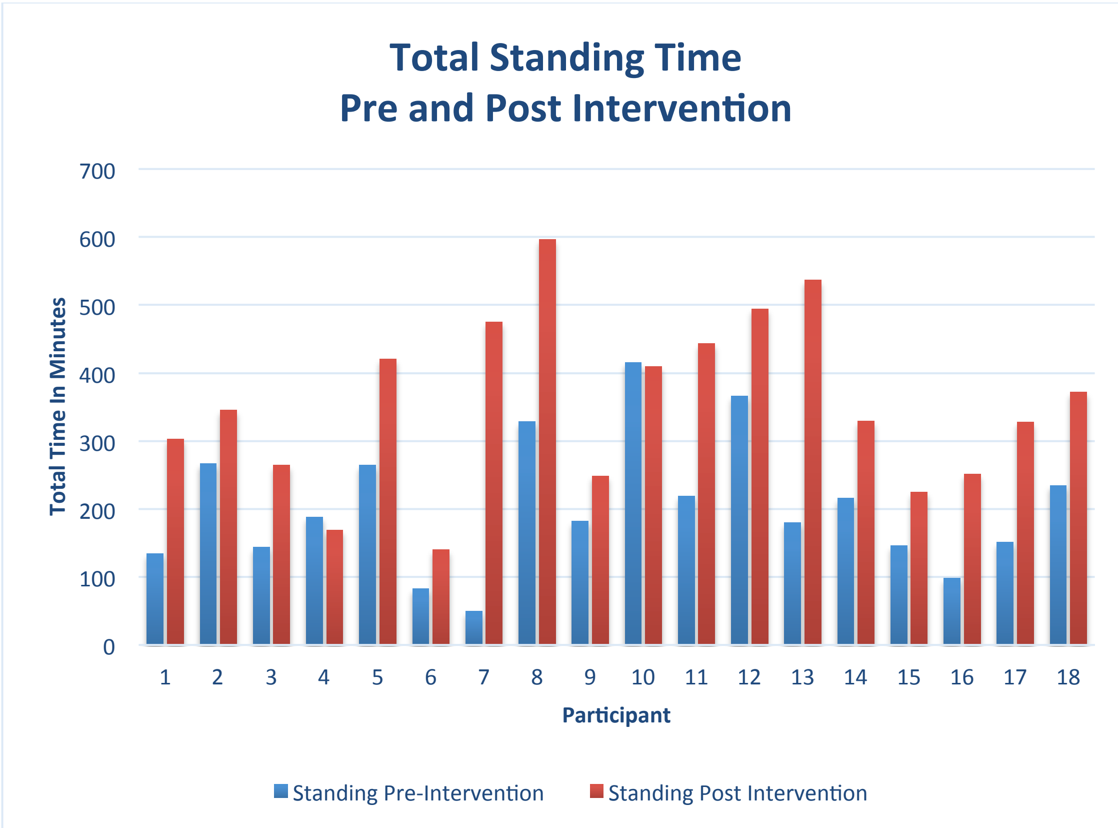

Figure 18 – Total Standing Time Pre and Post Intervention

Figure 19 shows the hour-by-hour averages for the eighteen participants in the study. For every hour, except the 11 a.m. hour, students, on average, stood more after stand-biased desks were installed in their school. The 11 a.m. hour is unique because it is the lunch hour at Bryan Collegiate High School. The times converge because all students are in the cafeteria during lunch and must stand in line for their food, causing their standing times to increase during their lunch period.

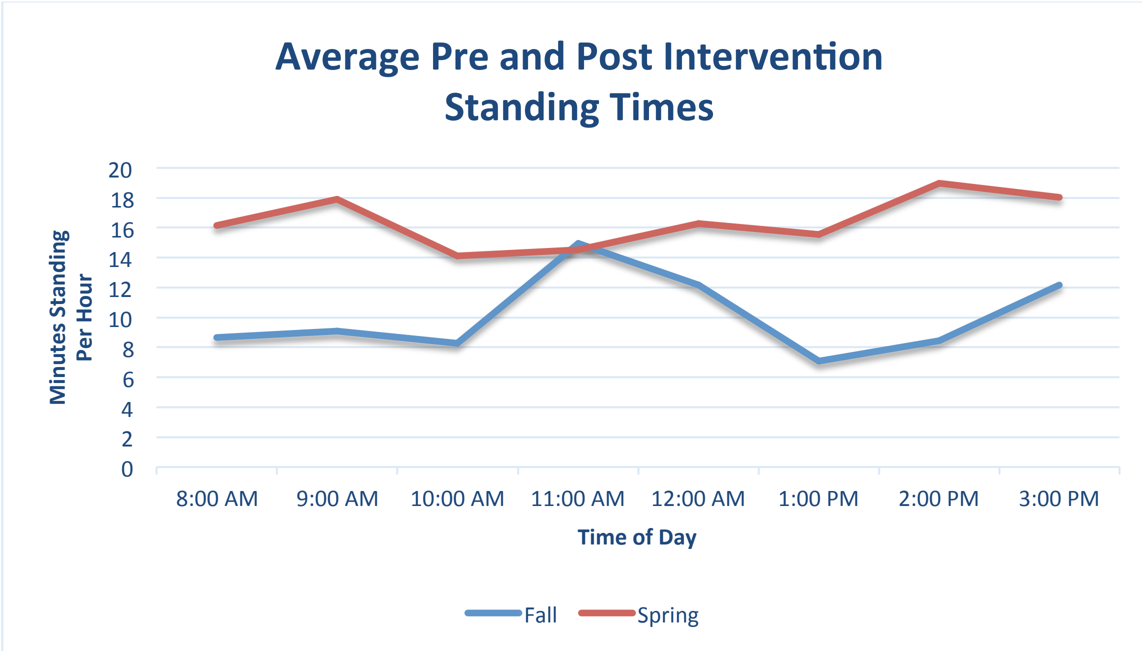

Figure 19 – Average Pre and Post Intervention Standing Times

Table 3: Standing Paired T-Test Results

N	Mean Difference	Standard Deviation	t Value	Pr > t
18	-149.2	113.9	-5.56	<0.0001

Table 3 shows the results of the Paired Student T-Test on the Pre and Post intervention data. The mean difference in standing minutes between pre and post intervention is -149.2 minutes (also seen in Table 4). The standard deviation between pre and post intervention times was 113.9 minutes. All data points for this study fall within 1 standard deviation. The T-Value of -5.56 supports statistically significant findings. This is supported by P<0.0001.

Table 4: Standing Summary Descriptive Statistics

N=18	Pre-Intervention	Post-Intervention	Delta
Mean Time Standing (In Minutes)	203.7	353	149.2

Table 4 shows that over the 22-hour period (approximately 3 school days) of pre and post intervention testing, students, on average stood approximately 2.5 hours more after the stand-biased desk intervention over three 8-hour school days. This is about 50 minutes of additional standing per school day. The deltas between total sitting time and total standing time are slightly different. This can be attributed to students adding additional walking time after the standing desk intervention

Limitations

The main limitation of this pilot study is sample size. Eighteen participants only give a small snapshot of the school population as a whole. It is difficult to make broad generalizations with a limited sample size. The small sample size also causes a large standard deviation in both the sitting and standing data sets. Another limitation of the study is inherent to research in schools. No two teachers are alike. Some teachers promote an active classroom, and other teachers have a more sedentary classroom. It is impossible to control for teacher influence in a real world setting. Finally, this pilot study took a broad view of the school day, and did not look at individual differences between individual classes. This study was conducted over two semesters, subsequently, the students did not have identical pre-intervention and post-intervention schedules.

CONCLUSIONS

This thesis study examined the impact of standing desks on the sedentary behavior of high school students during the school day. The data indicates roughly 175 minutes of reduced seated time over 1040 seated school minutes, a 17% reduction in sitting time post intervention. The data also indicates a 150-minute increase in standing time over 204 school minutes, a 73% increase in standing time. There is a 25 minute difference between reduced seated time and increased standing time. This can be explained by an increase in student movement. There was no control for student movement in this study, and therefore, it was not considered in the data analysis. Overall, there is decrease in sedentary time and an increase in active time for high school students after the stand-biased desks were installed in their classrooms.

Decreasing sedentary behavior and increasing activity can only be seen as a positive for high school students. Sedentary behavior has been identified as a significant factor in childhood and adolescent obesity. Research by Jansen et al. (2005) found that,

> "The two countries with the highest prevalence of overweight (pre-obese + obese) and obese youth were Malta (25.4% and 7.9%) and the United States (25.1% and 6.8%) while the two countries with the lowest prevalence were Lithuania (5.1% and 0.4%) and Latvia (5.9% and 0.5%). Overweight and obesity prevalence was particularly high in countries located in North America, Great Britain, and south-western Europe. Within most countries physical activity levels were lower and television viewing times were higher in overweight compared to normal weight youth."

The fact that childhood and adolescent obesity is correlated with low activity levels should not be surprising. A child with low activity levels must maintain a strict diet in order to balance caloric intake and energy expenditure, and this is difficult to achieve. Cutting an hour of sedentary behavior during the school day, without taking away from instruction time, requiring additional school personnel, or additional training is an easy way to help kids slow, or even reverse the effects of sedentary behavior.

Stand-biased desks in classrooms are by no means the “magic pill” for adolescent obesity. However, they can play an integral role in reducing sedentary behavior and increasing active behavior during the school day. Modifying the school environment to encourage activity can only be seen as a positive in the battle against obesity.

Finally, based on teacher and student comments, stand-biased desks have additional utility to students and teachers. Teachers report having fewer students attempting to sleep in class because the stand-biased desk does not allow students to slump over in their chairs. Students are also able to self-regulate and stand up when they become tired instead of slowly drifting off to sleep. Teachers at the school also report that students who want to stand up and move around in class are less disruptive in standing desks because they are actually encouraged to stand up at their desks and move around. The teachers have found this especially helpful during long standardized tests, where students are required to work for long periods of time with limited breaks. Stand-biased desks have utility outside of reducing sedentary behavior, which should make them more attractive to school districts.

This pilot study produced intriguing, but non-generalizable results. An additional study with more subjects is recommended to further investigate the effects of stand-biased desks on sedentary behavior in high school students over their fully 4 year high school career.

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